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A NEW OPHIDIROID FISH (GENUS *LUCIFUGA*)  
FROM A LIMESTONE SINK,  
NEW PROVIDENCE ISLAND, BAHAMAS<sup>1</sup>

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The ophidioid fish described here was collected in Mermaid's Pool, a little-known limestone sink near Nassau on New Providence Island in the Bahamas. Proper placement of this species required study of its closest known relatives, the two species of Cuban cave brotulids. We refer all three species to the genus *Lucifuga*, which is diagnosed below.

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*Lucifuga* Poey

*Diagnosis:* Chin barbel absent. Gill membranes separate. Live-bearing; male genitalia well-developed, lacking ossified parts. Ventral

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fins each with a single ray, immediately adjacent to each other, originating well behind the symphysis of the cleithra; the pelvic girdle not extending anteriorly to the symphysis of the cleithra. Connection between dorsal and anal and caudal fins variable in extent; caudal fin exserted, rays 8–11. Pectoral fin entire, without separate, elongated rays; not on an elongated peduncle. Dorsal-fin origin over centrum 8, 9 or 10, usually 9; a single predorsal rayless pterygiophore. Head partly naked, bearing prominent canals with large chambers. Head pores: 1 in lateral canal; 2 in supra-orbital; 6 in suborbital; 7 in preoperculo-mandibular. Anterior nostril directly above the upper lip. Developed gill rakers 3; tongue with an anterior prowlike extension. Spine on opercle flattened, weak, not visible exteriorly. Branchiostegal rays 7, 4 attached to outer surface of epihyal and enlarged distal portion of ceratohyal, 3 attached ventrally along shaft of ceratohyal. Body compressed; tail section not greatly elongated; snout depressed. Lateral line interrupted, the shorter, anterior part above midline of body, the posterior part in midline. Teeth present on pre-maxillary, vomer, and dentary; present or absent on palatine. Maxillary vertically expanded posteriorly, a small ventrally directed process near posteroventral angle. Eyes poorly developed, not externally visible in many preserved specimens. Body completely covered with small, imbricate scales.

First neural spine shorter than those following. Ribs apparently present on first centrum; centra 2 to 6 or 7 bearing ribs, the following abdominal centra with pleural ribs at the ends of parapophyses, with exception of last centrum which usually lacks them. Total vertebrae 46 to 53.

*Relationships:* We agree with Eigenmann (1909) and Hubbs (1938) that *Lucifuga* belongs in the large assemblage of viviparous ophidioid genera called Bromophycinae by some ichthyologists. The dermatopsin genera (Cohen, 1966) and the *Dinematichthys-Ogilbia* assemblage (including the Mexican cave genus *Typhliasina* Whitley = *Typhlias* Hubbs) can be dismissed as close relatives because of their ossified genital claspers. Among the many remaining genera, *Lucifuga* seems closest to some of the deep water species with depressed snouts, presently placed in *Cataetys* and *Diplacanthopoma*. Both of these genera are in the process of revision, hence detailed comparisons are not possible at present. Susceptible of brief mention, however, are similarities in body and head shape, copulatory apparatus, and ventral fin placement. Among shallow water genera, *Lucifuga* may have its closest known relative in *Calamopteryx* Böhlke and Cohen (1966), a small, secretive coral reef fish living in the tropical western Atlantic. Because it is a small fish with elongate pectoral radials, it is unlikely that *Calamopteryx* gave rise directly to *Lucifuga*. The common ancestor of both may await discovery, hidden in the crevices of a tropical Atlantic reef.

*Subgenera:* Poey (1858–1860) placed both species of Cuban cave brotulids in *Lucifuga*. Gill (1863) erected *Stygicola* for *L. dentatus* because of the presence of palatine teeth. This character notwithstand-

ing, the species of *Lucifuga* are very similar indeed and obviously are much more closely related to each other than to any other known brotulid. We believe that classification will be better served by referring all three species to a single genus, *Lucifuga*, which contains two subgenera. Hubbs (1938), in discussing *Typhliasina*, *Lucifuga* and *Stygicola* wrote, "All three genera are sharply differentiated by the detailed structure of the penis." It seems to us that differences between *Lucifuga* and *Stygicola* are of degree rather than kind.

#### Subgenus *Lucifuga*

*Lucifuga* Poey 1858, type species *L. subterraneus* Poey, by subsequent designation of Jordan and Evermann (1896).

*Diagnosis:* Palatine teeth absent. Pectoral fin rays 12 to 14, usually 12 or 13.

*Species:* *L. subterraneus*.

*Study Material:* USNM 204452 (2); USNM 126697 (1); UMMZ 157178 (54).

#### Subgenus *Stygicola*

*Stygicola* Gill 1863, type species *Lucifuga dentatus* Poey, by monotypy.

*Diagnosis:* Palatine teeth present. Pectoral fin rays 15 to 20.

#### *Lucifuga* (*Stygicola*) *dentatus* (Poey)

*Diagnosis:* Pectoral fin rays 15 to 17. Vertebrae 46 to 48. Scales absent on the area between lateral canal and preopercular canal.

*Study Material:* USNM 5334 (1); USNM 34632 (3); USNM 63992 (1); USNM 102160 (1); CAS 6714 (7).

#### *Lucifuga* (*Stygicola*) *spelaeotes* new species

Figs. 1, 2

*Diagnosis:* Pectoral fin rays 18 to 20. Vertebrae 52 to 53. Scales present on the area between lateral canal and preopercular canal.

*Description:* Measurements of the types of *L. spelaeotes* and of a representative series of *L. subterraneus* and *L. dentatus* are given in Table 1; frequency distributions of fin-ray and vertebral counts are presented in Table 2. In the account below, an asterisk indicates the condition in the holotype.

The dorsal profile is strongly arched, the highest point being at or slightly in advance of the dorsal-fin origin. The dorsum is broad and flattened from the dorsal fin to the snout tip with only a slight depression in the interorbital region. The sides are very flat and converge ventrally so that a cross section through the nape would be bluntly V-shaped. In dorsal view the snout is broadly rounded with the upper jaw somewhat projecting. The mouth is subterminal with the lower jaw only slightly shorter than the upper. The ventral profile is



FIG. 1. *Lucifuga spelaeotes*, USNM 204603; holotype; 109 mm SL. Drawn by Mildred H. Carrington.



FIG. 2. *Lucifuga spelaeotes*. USNM 204603; holotype; 109 mm SL. Detail of ♂ genital area; ventral view; anterior to the left; papilla proper and median 1 pushed forward, lobes spread apart; see text for explanation. Drawn by Mildred H. Carrington.

nearly straight with only a slight upturn to the caudal base. Posteriorly the body is compressed, elongate and evenly tapered to the tail.

The anterior nostril opens through a short tube positioned laterally on the anterior rim of the snout. The much larger posterior nostril is a triangular opening without raised margins, located about midway between the anterior nostril and the clear window in the skin covering the eye.

The eye is relatively well-developed though small and has a protruding lens which is easily seen through an elongate, clear window, several times larger than the eye. The horizontal diameter of this window is 3.5 or 3.6\* per cent of standard length, and the snout as measured to the forward edge of the window is 5.7 or 6.9\* per cent.

The vertical fins are confluent, though the caudal fin is exserted and

TABLE 1. Measurements in millimeters on the three species of *Lucifuga*.

|                                       | spelaeotes |        |        |        | subterraneus |        |        |        |        |        |        |        |
|---------------------------------------|------------|--------|--------|--------|--------------|--------|--------|--------|--------|--------|--------|--------|
|                                       | USNM       |        | USNM*  |        | UMMZ         |        | UMMZ   |        | USNM   |        | UMMZ   |        |
|                                       | ♀          | ♂      | ♀      | ♂      | ♀            | ♂      | ♀      | ♂      | ♀      | ♂      | ♀      | ♂      |
| Sex                                   | 204604     | 204603 | 102160 | 157178 | 157178       | 157178 | 157178 | 157178 | 102160 | 157178 | 157178 | 157178 |
| Standard length                       | 76.5       | 109    | 40.0   | 60.2   | 67.5         | 70.9   | 72.5   | 72.5   | 72.8   | 74.6   | 76.0   | 81.5   |
| Head length                           | 21.2       | 33.1   | 11.1   | —      | 18.7         | 18.6   | 19.7   | 18.3   | 18.3   | 20.5   | 20.9   | 22.1   |
| Body depth <sup>1</sup>               | 15.3       | 23.8   | 6.5    | —      | 14.3         | 14.1   | 16.3   | 12.0   | 15.4   | 17.1   | 16.0   | —      |
| Jaw length <sup>2</sup>               | 10.1       | 17.9   | 5.0    | 7.8    | 8.3          | 9.1    | 9.2    | 8.4    | 8.4    | 9.3    | 9.2    | 10.6   |
| Depth of maxilla <sup>3</sup>         | 3.4        | 6.2    | 1.6    | 2.4    | 3.3          | 2.9    | 3.1    | 2.8    | 3.6    | 3.6    | 3.5    | 3.6    |
| Snout to dorsal-fin origin            | 27.6       | 43.9   | —      | 24.4   | 27.5         | 28.9   | 29.0   | 28.7   | 28.7   | 30.6   | 29.8   | 32.2   |
| Snout to anal-fin origin              | 37.6       | 61.5   | —      | 31.1   | 35.8         | 35.9   | 36.5   | 37.6   | 37.6   | 37.9   | 38.8   | 40.5   |
| Pectoral-fin length                   | 9.7        | 13.2   | —      | —      | 8.0          | 8.2    | —      | 7.5    | —      | —      | —      | —      |
| Ventral-fin length                    | 7.3        | 14.3   | —      | 3.8    | 6.2          | 4.0    | 3.6    | —      | —      | —      | 4.3    | 4.8    |
| Cleithrum to ventral fin <sup>4</sup> | 3.5        | 5.0    | 1.4    | 2.9    | 3.0          | 3.5    | 3.6    | 3.2    | 3.2    | 4.0    | 4.9    | 4.8    |

<sup>1</sup> Greatest depth.<sup>2</sup> Snout tip to posterior edge of maxilla.<sup>3</sup> Greatest distance across expanded posterior end of maxilla.<sup>4</sup> Symphysis of cleithra to origin of ventral fin.

\* Holotype.

TABLE 1. (Continued)

|                                       | dentatus    |             |             |               |             |             |              |             |             |                |
|---------------------------------------|-------------|-------------|-------------|---------------|-------------|-------------|--------------|-------------|-------------|----------------|
|                                       | CAS<br>6714 | CAS<br>6714 | CAS<br>6714 | USNM<br>63992 | CAS<br>6714 | CAS<br>6714 | USNM<br>5334 | CAS<br>6714 | CAS<br>6714 | USNM<br>102160 |
| Sex                                   | ♂           | ♂           | ♂           | ♂             | ♂           | ♂           | ♂            | ♂           | ♂           | ♂              |
| Standard length                       | 76.1        | 87.0        | 88.3        | 95.7          | 98.9        | 99.1        | 100          | 101         | 106         | 118            |
| Head length                           | 21.9        | 24.4        | 25.2        | 27.8          | 27.9        | 27.4        | 26.8         | 28.6        | 29.2        | 31.5           |
| Body depth <sup>1</sup>               | 15.3        | 17.2        | 21.3        | 21.1          | 22.4        | 20.9        | 21.8         | 22.5        | 22.8        | 24.8           |
| Jaw length <sup>2</sup>               | 10.6        | 13.0        | 13.6        | 15.5          | 15.2        | 15.0        | 14.5         | 16.4        | 15.9        | 18.4           |
| Depth of maxilla <sup>3</sup>         | 4.1         | 4.6         | 5.1         | 5.8           | 5.3         | 5.3         | 5.3          | 5.7         | 5.3         | 7.1            |
| Snout to dorsal-fin origin            | 29.8        | 34.5        | 34.7        | 39.2          | 38.8        | 39.2        | 40.6         | 41.2        | 41.7        | 46.9           |
| Snout to anal-fin origin              | 39.0        | 47.0        | 46.4        | 52.3          | 52.8        | 53.5        | 53.1         | 53.6        | 55.4        | 62.6           |
| Pectoral-fin length                   | 9.3         | 9.7         | 11.5        | —             | 12.5        | 10.4        | —            | —           | —           | 15.0           |
| Ventral-fin length                    | 5.3         | 6.1         | 8.0         | 5.3           | —           | 7.0         | —            | 9.1         | 7.3         | 7.0            |
| Cleithrum to ventral fin <sup>4</sup> | 4.0         | 5.5         | 4.8         | —             | 5.9         | 5.5         | 5.5          | 5.1         | 6.1         | 6.1            |

<sup>1</sup> Greatest depth.<sup>2</sup> Snout tip to posterior edge of maxilla.<sup>3</sup> Greatest distance across expanded posterior end of maxilla.<sup>4</sup> Symphysis of cleithra to origin of ventral fin.

\* Holotype.

TABLE 2. Frequency distributions of numbers of fin-rays and vertebral centra in *Lucifuga*.

|                                | Dorsal rays   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | Anal rays              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |
|--------------------------------|---------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|
|                                | 80            | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 61                     | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 |  |
| <i>subterraneus</i>            | 1             | 2  | 3  | 1  | 2  | -  | 21 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | 1                      | 1  | -  | -  | 1  | 2  | -  | 2  | 1  | 1  | -  | 1  | -  | -  | -  | -  | -  |    |  |
| <i>dentatus</i>                | -             | -  | -  | 2  | 1  | 1  | -  | -  | -  | 1  | 1  | 1  | 1  | 1  | 2  | 1  | -  | -  | -  | -                      | -  | -  | -  | -  | -  | -  | -  | 1  | 1  | 2  | 1  | 1  | 2  | -  | -  | 1  |    |  |
| <i>spelaeotes</i>              | -             | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | 1* | -  | -  | -  | -  | -  | -  | -                      | -  | -  | -  | -  | -  | -  | -  | -  | 1* | 1  | -  | -  | -  | -  | -  |    |    |  |
|                                |               |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                        |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |
|                                | Pectoral rays |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | Vertebrae <sup>a</sup> |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |
|                                | 12            | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |    |    |    |    |    |    |    |    |    |    | 46                     | 47 | 48 | 49 | 50 | 51 | 52 | 53 |    |    |    |    |    |    |    |    |    |    |  |
| <i>subterraneus</i>            | 9             | 4  | 1  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | 4                      | 9  | 1  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |    |    |  |
| <i>dentatus</i>                | -             | -  | -  | 2  | 7  | 4  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | 4                      | 6  | 3  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |    |    |  |
| <i>spelaeotes</i> <sup>1</sup> | -             | -  | -  | -  | -  | -  | 2* | 1  | 1  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -                      | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | 1* | 1  | 1  |    |    |  |

\* Holotype.

<sup>1</sup> Both sides counted.<sup>2</sup> Ural centra not counted.

easily distinguished. The dorsal fin is highest posteriorly, the anal fin of about equal height throughout. The pectoral fin is elongate and pointed, its central rays longest. Its base is vertical and mounted on a broad fleshy pad. The branchiostegal and opercular membranes cover most of the fin base, and reach nearly to the rays themselves. Most pectoral rays, all anal rays except the anterior 1 or 2, and all dorsal rays except a few anteriorly, are branched once. The single pelvic ray is undivided and filamentous, though short, reaching about half way to the anus.

The entire body, including the isthmus and the pectoral-fin base is covered with small, rounded cycloid scales. There are about 23 rows in a series across the body above the anal-fin origin. The branchiostegal membranes, the entire underside of the head, the jaws, the snout, the interorbital areas, the entire course of the cavernous cephalic lateralis system and the sides of the head forward of the posterior edge of the maxilla, are naked. The naked area over the preopercular canal is disjunct from the naked area along the lateral canal, with the intervening area bearing scales; thus the scaly area of the opercle is continuous dorsally with the scaly area anterior to the preopercle. The opercle, the sides of the head from the preopercular margin to the maxilla and the occiput bear scales, except for those portions over the head canals. Except for a few scales at the base of the pectoral rays, all fins are naked.

There is no pored lateral canal on the body, but the sensory papillae are well-developed and in two series. The upper and anterior series of 14 papillae extends caudally from the head to a point about midway between the dorsal- and anal-fin origins. The lower row of about 38\* to 42 papillae extends along the mid side from the caudal base to a point under and slightly in advance of the end of the upper series. The head canals are cavernous and the openings are large. There are 7 pores in the preoperculo-mandibular series: the first and largest at the angle of the preopercle, the second to fourth open ventrally along the mandibular ramus, the fifth is directed mesially at the anterior end of the mandibular ramus and the sixth is at the side of the jaw tip on the lower lip; the last pore is hidden in the fold of skin between the lip and the mandibular ramus and opens from the ramus into this fold. The two canals do not join anteriorly. There are 6 pores in the suborbital series. The first 5, slitlike, along the edge of suborbital rim, the last, circular, between and slightly below the two nasal openings. The posterior of the two pores in the supraorbital canal opens between and mesial to the nasal openings, the anterior at the snout rim. The single pore in the lateral canal is at the posterior end of the tube above the opercle.

The lower jaw in the holotype is abnormal in that it bears a fleshy, multidigitate growth on the lower lip near the symphysis of the dentary. There is also a large fleshy pad (absent in the female) on the outside of the mouth at the tip of the lower jaw.

The naked skin covering many of the mucous chambers on the head

is an almost iridescent white. This is particularly striking on the dorsal-most chamber of the preopercular canal and the posterior chambers of the lateral canals.

The opening behind the fourth gill arch is restricted to a slit along the lower arm of the arch. There are 3 short rakers on the upper part of the lower limb of the first arch plus 13 low dentigerous pads, the upper 2 of which are between the developed rakers. Four similar pads are present on the upper limb. A pseudobranch is absent. The tongue is free and elongated anteriorly, its tip fitting into a median groove in the vomer when the mouth is closed.

Teeth are present on the premaxillae, dentaries, vomer and palatine. Those in the jaws are short, villiform, and in broad patches. The vomerine tooth patch is nearly divided by a median groove and the teeth are somewhat elongate, needlelike and arranged in a whorl. The palatine teeth are similar and are restricted to the anterior end of the bone.

There is a rounded ethmoid projection and a single, flattened opercle spine, neither of which is visible externally.

Ribs are present on centra 1 to 7; subsequent abdominal centra except the last have pleural ribs at the ends of parapophyses. Epipleural ribs are presently; however, our x-ray photographs do not allow precise description of their distribution.

There are 13 precaudal and 39\* or 40 caudal vertebrae, total 52\* or 53, exclusive of the ural centrum.

Of the 7 branchiostegals, the posterior 4 attach to the outer surface of the epihyal and enlarged distal portion of the ceratohyal; the anterior three attach ventrally to the shaft of the ceratohyal.

The posterior end of the maxilla is vertically expanded and unsheathed dorsally; its posterior edge is convex, ending below in a distinct projection or hook.

The male copulatory apparatus is well-developed and lacks ossification. It is borne on a broad, fleshy lobe (the "papilla proper" of Hubbs, 1938) which projects posteriorly beyond the vent. A fleshy conical papilla (here called median 1) projects posteriorly from the middle of the distal margin of the lobe. Anterodorsal to median 1 is another, small papilla, the "median process" (Hubbs, 1938), which is enclosed by prominent, earlike lobes. These lobes are partly divided into a larger section ("secondary lobe" of Hubbs, 1938), immediately dorsal to median 1, and a smaller section ("basal lobe" of Hubbs, 1938) which is slightly dorsal and medial to the first section and which extends anteriorly and meets its mate in the midline anterior to the median process. Although better developed, the entire copulatory apparatus is basically similar to that in mature males of *L. dentatus* and *subterraneus* which we have examined. We can not readily reconcile our observations with the figure of *dentatus* presented by Hubbs (1938, pl. 3) and suggest that his specimen was immature.

There are two, short pyloric caeca.

*Color:* Except as noted below the entire fish is a rich walnut brown, the color in preservative differing but little from life colors according to Dr. Ray. The margins of the vertical fins are whitish, this light-colored border widest posteriorly and in the smaller female. The pectoral fins, the ventral ray, the lips and the skin over the cephalic lateralis system, are all unmarked or distinctly whitish. The branchiostegal membranes are whitish posteriorly but dark along the isthmus. The orobranchial chamber, the gut and the peritoneum are all unmarked.

*Etymology:* From the masculine Greek noun, *spelaeotes*, a cave or cavern dweller, in reference to its habitat.

*Material examined:* Holotype, USNM 204603, an adult male, 109 mm SL Bahamas, New Providence Island, Mermaid's Pool, depth 5 meters, 24 October 1967, collected by Carleton Ray. Paratype, USNM 204604, a female, 76.5 mm SL, collected with the holotype.

*Habitat:* Mermaid's Pool is a small sink in the limestone area SW of Nassau. The vegetation, where not cleared for a housing development, is predominantly pine and scrub growth. The main pool is about 75 feet across, and several small openings are nearby. Grapsoid crabs live on the steep walls. The water level is several feet below the surface and represents the exposed water table. Salinity of a water sample taken by Dr. Ray just below the surface (ca. 1 meter), tested at the Institute of Marine and Atmospheric Sciences, was 4.6 ppt.

The area of Mermaid's Pool is in a large tract of land already largely cleared for a housing development; the future of the Pool and its water quality is uncertain.

*Discussion:* *L. spelaeotes* appears to be the most primitive of the three known species of the genus. Of particular significance are the presence of palatine teeth, a greater number of caudal fin rays (10 to 11 instead of 8 as in the other two species), relatively well-developed eyes in the adult and a distinctly dark coloration. *L. dentatus* is surely closest to *spelaeotes*, sharing with it the possession of palatine teeth. *L. dentatus* is usually, although not always, a paler fish. Eigenmann (1909) described the color as varying "from pinkish lilac to steel-blue, with transparent edges to the fins." He mentioned, however that dark specimens are also found, and illustrated them (pl. 13). Color photographs of live specimens published as the result of a recent Italian Expedition to Cuba (A.O. 1968) show an almost white fish with a dark blotch on one of the vertical fins near the tail and pale brown pigmentation on the dorsum and part of the head. We have seen no specimens of *dentatus* or *subterraneus* with developed eyes, although Eigenmann mentioned that the eye is variable in size and smaller in older individuals. *L. subterraneus* is surely the most specialized species with its lack of palatine teeth, smaller size, generally pale color ("faint pink to lilac pink and lilac," according to Eigenmann) and marked depression above the orbits—the last character shared with *dentatus*. A direct phyletic line is unlikely,

for several disjunct characters are also present. For example, *spelaeotes* and *subterraneus* have the area between preopercular and lateral canals covered with scales; in *dentatus* this area is naked. Also, both *spelaeotes* and *subterraneus* have a scaly patch on the occiput (though the scales are imbedded and difficult to see in the latter); *dentatus* has a naked occiput.

Reports are extant of still other populations of blind cave fishes in the West Indies, one on Eleuthera in the Bahamas and another at Jamaica. Collections from these islands will surely add to knowledge of the phylogeny of the species of *Lucifuga* and may well contribute significant data to zoogeography and to the study of speciation and evolution in cavelike environments.

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